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## HEAVY ION INVESTIGATIONS

Richard D. Sharp

Lockheed Missiles and Space Company,  
Incorporation

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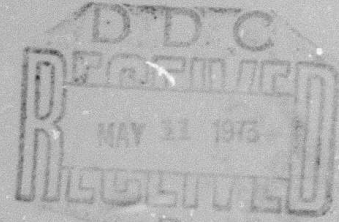
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(For period 1 November 1972 through 28 February 1973)

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HEAVY ION INVESTIGATIONS

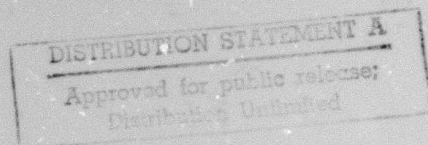


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<p>This is a program for the analysis of selected data from the ARPA Energetic Ion Mass Spectrometer Experiment on the OV1-18 satellite. This experiment provided the first evidence for energetic magnetospheric ions with <math>m &gt; 4</math> that have recently been inferred to be <math>O^+</math> ions and to be an important new magnetospheric particle population (Shelley et al., 1972). During this quarter, a comparison of the latitudinal position of the energetic <math>O^+</math> ions with the inferred location of the plasmopause was made for three magnetic storms in 1969. The results show that the ions lie poleward of that boundary and are not responsible for the direct excitation of SAR-arcs. In the 24 December 1969 storm where detailed ionospheric data are available, the energetic <math>O^+</math> ions were found to be located near a steep ionospheric gradient. Plasma instabilities generated at this gradient could be the source mechanism for the acceleration of ambient ionospheric <math>O^+</math> ions into the 10-keV range.</p>			

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Report Summary

This is a program for the analysis of selected data from the ARPA Energetic Ion Mass Spectrometer Experiment on the OVI-18 satellite. This experiment provided the first evidence for energetic magnetospheric ions with  $m > 4$  that have recently been inferred to be  $O^+$  ions and to be an important new magnetospheric particle population (Shelley et al., 1972). During this quarter, a comparison of the latitudinal position of the energetic  $O^+$  ions with the inferred location of the plasmopause was made for three magnetic storms in 1969. The results show that the ions lie poleward of that boundary and are not responsible for the direct excitation of SAR-arcs. In the 24 December 1969 storm where detailed ionospheric data are available, the energetic  $O^+$  ions were found to be located near a steep ionospheric gradient. Plasma instabilities generated at this gradient could be the source mechanism for the acceleration of ambient ionospheric  $O^+$  ions into the 10-keV range.

Quarterly Progress

The storms of 24 March 1969, 15 May 1969, and 30 September 1969 were selected for initial study because of their substantial  $O^+$  fluxes and the availability of ground and satellite observations of relevant phenomena for comparison. Principal among these is the latitudinal position of the stable auroral red arcs (SAR-arcs) which have been shown to mark the location of the plasmopause (Chappell et al., 1971; Hoch and Smith, 1971; Carpenter et al., 1971).

In our initial studies of the newly-discovered  $O^+$  energetic ions (Shelley et al., 1972), it was noted that their morphology bore a striking similarity to that of the SAR-arcs and the possibility of a relationship was suggested. In any case the spatial relationship of the energetic  $O^+$  ions to the plasmopause is of considerable interest. A comparison with the SAR-arc observations of Kleckner and Hoch (1972) during the three above-mentioned storms has indicated that the energetic  $O^+$  ions lie poleward of the SAR-arcs, and inferentially the plasmopause, by about one L unit and are spatially associated with the mid-latitude hydrogen arcs reported by these observers.

The availability of ambient ion density data from the on-board ion trap on the OV1-18 spacecraft (G. Sharp, 1971) has allowed a comparison between the location of the energetic  $O^+$  ions and the observed horizontal ion gradients in the F-region on two orbits during the 24 March 1969 storm. On the pass near 0 hours UT on 24 March, when the most intense energetic  $O^+$  fluxes were observed, they were located at the position of a steep gradient in the ambient cold plasma density. This is suggestive of the possibility that plasma instabilities generated at this gradient could be responsible for the energization of the  $O^+$  ions into the 10-keV range.

In the 15 May 1969 storm, in addition to SAR-arc observations, OGO-4 and OGO-6 data are available (Scarf et al., 1972). Strong electrostatic emissions suggestive of wave particle interactions were reported outside the plasmopause in the afternoon sector at about the same L shell that the energetic  $O^+$  ions were observed on in the midnight sector. The implications of this finding are still under consideration.

Preliminary statistical studies on 13 events have shown that the peak  $O^+$  intensities are fairly uniformly distributed in magnetic local time over the range of about 20 hours to 04 hours. The distribution in L shows a broad peak at about  $L = 5$ . The distribution in pitch angle of the peak flux observations shows no evidence for a deviation from isotropy over the upper hemisphere. These preliminary results will be reported at the Spring Meeting of the American Geophysical Union in Washington, D.C. The Abstract is included as Appendix A.

#### REFERENCES

- Carpenter, D. L., J. Geophys. Res., 76, 3644, 1971.
- Chappell, C. R., K. K. Harris and G. W. Sharp, J. Geophys. Res., 76, 2357, 1971.
- Hoch, R. J., and L. L. Smith, J. Geophys. Res., 76, 3079, 1971.
- Kleckman E. W., and R. J. Hoch, preprint, 1972.
- Scarf, F. L., R. W. Fredricks, E. J. Smith, A. M. A. Frandsen, and G. P. Serbu, J. Geophys. Res., 77, 1776, 1972.
- Sharp, G. W., Final Report, Contract N00014-70-C-0234, Lockheed Missiles and Space Company, 1971.
- Shelley, E. G., R. G. Johnson, and R. D. Sharp, J. Geophys. Res., 77, 6104, 1972.

## APPENDIX A

### OBSERVATIONS OF ENERGETIC HEAVY IONS NEAR SOLAR MAXIMUM

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#### ABSTRACT

Heavy ions with energies between 1 and 9 keV have frequently been detected with an energetic ion mass spectrometer on the satellite 1969-25B during the period March 1969 to August 1970. Their identification as  $O^+$  ions of the ionospheric origin has been inferred from a comparison with the more complete mass measurements with an improved spectrometer on the satellite 1971-089A, and from considerations of ionospheric and solar wind abundance ratios. Data from nine magnetic storms have been analyzed, and the peak responses occurred at L values between 3.4 and 6.4, and at magnetic local times between 21.8 and 4.5 hours. A maximum flux of approximately  $0.1 \text{ erg/cm}^2\text{-sec-sterad}$  was observed during the March 23-24, 1969 storm.